



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
COBB BAY CREEK CULVERT REPLACEMENT  
HIGHWAY 599, SITE No. 48W-190/C  
DISTRICT OF KENORA  
ONTARIO  
G.W.P. No. 6839-14-00**

**GEOCRES Number: 52J-17**

**Latitude 50.020074 ° , Longitude -90.995573 °**

**Report**

to

**HATCH Corporation**

Date: February 8, 2018  
File: 17077



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ONTARIO**

**G.W.P. No. 6839-14-00**

**GEOCRES Number: 52J-17**

**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Cobb Bay Creek Culvert on Highway 599, located in the District of Kenora.

The purpose of this investigation was to explore the subsurface conditions at the culvert site and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch Corporation (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0030.

**2. SITE DESCRIPTION**

The site is located on Highway 599, approximately 30.8 km north of the intersection of Highway 599 and Highway 642 in Silver Dollar, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata Drawings in Appendix D.

Highway 599 runs in a general northeast-southwest direction with the culvert generally perpendicular to the centreline of the highway. The culvert allows Cobb Bay Creek to flow in an southerly direction beneath the highway.

The Ontario Structural Inspection Manual (OSIM) prepared by MTO dated November 2, 2015 indicates that the existing structure is a 17 m long, two span open footing, timber structure culvert. Each span is 2.4 m wide. The timber culvert is 1.7 m high. The grade level of Highway 599 at the

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existing culvert is at an approximate Elevation of 425.1 m. The height of the existing fill cover is approximately 0.5 m. The culvert invert is at approximately Elevation 422.9 m at the inlet and 422.8 m at the outlet. The upstream and downstream water levels of Cobb Bay Creek were measured at Elevation 423.51 m and 423.50 m, respectively, in April 2016, as shown on drawings provided by Hatch.

The lands surrounding the Cobb Bay Creek Culvert site predominantly consist of heavily forested areas with occasional marsh lands and lakes. Local topography consists of plains generally of low relief. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils at the site generally consist of glaciolacustrine plains of sands and silts overlying shallow knobby and hummocky bedrock of moderate relief. Bedrock geology maps of the area show that the site lies on a border of bedrock comprising of mafic to intermediate metavolcanics rocks and bedrock comprising of felsic to intermediate metavolcanics rocks.

### **3. INVESTIGATION PROCEDURES**

The borehole investigation and field testing program for this project was carried out between July 9 and July 20, 2017 and consisted of drilling and sampling seven (7) boreholes, designated as Boreholes CO17-01 to CO17-05, CO17-07 and CO17-08. Two attempts were made to advance Borehole CO17-07 to an appropriate depth and are designated as CO17-07A and CO17-07B. Boreholes CO17-01 to CO17-03 were drilled along the culvert alignment. Boreholes CO17-01 and CO17-03 were drilled at the inlet and outlet, respectively, and terminated upon refusal at 7.7 m and 9.9 m (Elevation 416.0 and 413.6). Borehole CO17-02 was drilled through the highway embankment. Bedrock was proved by NQ size diamond in Borehole CO17-02. Borehole CO17-02 was advanced 3.4 m into bedrock and terminated at 11.3 m depth (Elevation 413.8).

Due to the site constraints and difficult access to the borehole location, the drilling operations for Borehole CO17-01 were conducted using portable tripod equipment. The tripod equipment allowed us to drill at the proposed borehole location, however it encountered refusal and was not able to advance further. Multiple attempts were made in the area to advance the borehole deeper, but were unsuccessful.

Boreholes CO17-04, CO17-05, CO17-07 and CO17-08 were drilled through the paved section of Highway 599, to the east and west of the existing culvert, at approximately 10.0 m intervals. These boreholes were advanced to assess the existence and extents of any frost taper near the culvert.



Boreholes CO17-04, CO17-07A, CO17-07B, and CO17-08 were terminated at depths ranging from 1.2 m to 3.7 m (Elevations 423.9 to 421.4). Borehole CO17-05 was located approximately 10 m west of the existing culvert centreline, near the alignment of the proposed creek diversion pipe. Bedrock was proved by NQ size diamond in Borehole CO17-05; it was advanced 3.2 m into bedrock and terminated at 11.7 m depth (Elevation 413.4).

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were derived from cross sections and topographic drawings provided to Thurber by Hatch. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

All boreholes within Highway 599 were drilled using a rubber track mounted drill rig equipped with continuous flight hollow and solid stem augers. Borehole CO17-01 was drilled using the wash boring method on tripod equipment. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined. Photos of the rock cores are included in Appendix B.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and upon completion of drilling. Upon completion of drilling operations, the boreholes were backfilled in general accordance with Ontario Regulation 903. Completion details of the boreholes are summarized in Table 3.1.



**Table 3.1 – Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Completion Details</b>
CO17-01	7.7 / 416.0	Borehole backfilled with bentonite holeplug to surface.
CO17-02	11.3 / 413.8	Borehole backfilled with bentonite holeplug to 6.1 m, gravel from 6.1 m to 0.4 m, cement to 0.05 m, then asphalt patch to surface.
CO17-03	9.9 / 413.6	Borehole backfilled with bentonite holeplug to surface.
CO17-04	3.7 / 421.4	Borehole backfilled with auger cuttings and asphalt patch to surface.
CO17-05	11.7 / 413.4	Borehole backfilled with bentonite holeplug to 6.1 m, gravel from 6.1 m to 0.1 m, then asphalt patch to surface
CO17-07A	1.2 / 423.9	Borehole backfilled with auger cuttings and gravel to 0.2 m, then asphalt cold patch to surface.
CO17-07B	1.5 / 423.6	Borehole backfilled with auger cuttings and gravel to 0.2 m, then asphalt cold patch to surface.
CO17-08	1.5 / 423.6	Borehole backfilled with auger cuttings and gravel to 0.2 m, then asphalt cold patch to surface.

#### **4. LABORATORY TESTING**

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer). The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point



load tests on the rock core samples are included in Appendix B and on the Record of Borehole sheets in Appendix A.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native soil, and a sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

## **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and should be used for interpretation of site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered below the existing embankment fill typically consist of layers of silt, sandy silt and, sand and silt overlying bedrock. Layers of peat and organic deposits were also encountered immediately underlaying the embankment fill in three boreholes. Descriptions of the individual strata are presented below.

### **5.1 Asphalt**

The boreholes that were drilled through the paved portion of Highway 599 encountered approximately 25 mm of asphalt at the ground surface. The ground surface elevation of the boreholes drilled on the highway platform was 425.1.

### **5.2 Embankment Fill**

Embankment fill consisting of sand and gravel to sand with trace silt and clay, was encountered below the asphalt in all boreholes drilled on Highway 599. The thickness of the embankment fill, where fully penetrated, ranged from 1.5 m to 2.4 m and extended to depths of 1.5 m to 2.4 (Elevations 423.6 to 422.7).



Boreholes CO17-07A, CO17-07B and CO17-08 were terminated within the embankment fill (upon auger refusal) at 1.2 m to 1.5 m depth (Elevations 423.9 to 423.6).

SPT 'N' values in the fill ranged from 7 to 24 blows for 0.3 m of penetration, indicating a loose to compact relative density. Measured moisture contents ranged from 3 to 22 percent.

An SPT 'N' value of 50 blows with no penetration, was measured in Borehole CO17-07B, indicating auger refusal.

The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Sand and Gravel Fill (percent)
Gravel	36 to 57
Sand	37 to 56
Silt & Clay	6 to 8

### 5.3 Peat and Sandy Silt with Organics

Sandy silt with organics was encountered in Boreholes CO17-01 and CO17-03 at the surface. The sandy silt with organics extended to depths of 0.6 m to 1.2 m (Elevations 422.9 to 422.5).

SPT 'N' values in the sandy silt with organics ranged from 2 to 8 blows for 0.3 m penetration, indicating a very loose to loose relative density. The measure moisture content if the sandy silt with organics was 48 percent.

A layer of dark brown, fibrous peat, containing roots and rootlets, trace sand was encountered below the embankment fill in Boreholes CO17-02, CO17-04, and CO17-05 at a depth of 1.5 m to 2.4 m (Elevation 423.6 to 422.7). The peat below the embankment fill was approximately 0.6 m to 1.2 m thick and extended to depths of 2.3 m to 3.0 m (Elevation 422.8 to 422.1).

SPT 'N' values in the peat ranged from 1 to 4 blows for 0.3 m penetration, indicating a very loose to loose state. Measured moisture contents of the peat ranged from 56 percent to 144 percent.



## 5.4 Silt

Layers of silt, containing trace sand and trace to some clay, were encountered below the peat or sandy silt with organics at depths ranging from 0.6 m to 4.0 m (Elevations 422.9 to 421.1) in Boreholes CO17-01 to CO17-05. Where fully penetrated the silt was 2.4 m to 4.9 m thick and extended to depths of 3.6 m to 8.5 m (Elevations 420.1 to 416.6).

Borehole CO17-04 was terminated within the silt layer at 3.7 m depth (Elevation 421.4).

SPT 'N' values recorded in the silt ranged from 1 to 46 blows for 0.3 m penetration, indicating a very loose to dense consistency. In general, the silt formation was denser at a higher elevation and looser with depth. The loose to very loose conditions were noted within approximate Elevations 420.5 to 417.0, and may have been the result of hydraulic ground disturbance during drilling operations. Measured moisture contents in the silt ranged from 16 percent to 31 percent.

The results of grain size distribution analyses conducted on samples of the silt are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B2 in Appendix B.

Soil Particle	Silt (percent)
Gravel	0
Sand	0 to 4
Silt	80 to 92
Clay	8 to 20

## 5.5 Sandy Silt to Sand and Silt

Layers of sandy silt, containing trace clay and gravel, were encountered below the silt formations at depths of 3.6 m and 4.6 m (Elevations 420.1 and 418.9) in Boreholes CO17-01 and CO17-03, respectively. A layer of sand and silt was encountered below the peat layer at a depth of 3.0 m (Elevation 422.1) in Borehole CO17-05.

Boreholes CO17-01 and CO17-03 were terminated within the sandy silt on auger refusal at depths of 7.7 m and 9.9 m (Elevation 416.0 and 413.6), respectively. The sand and silt layer in Borehole CO17-05 was approximately 1.0 m thick and extended to a depth of 4.0 m (Elevation 421.1).



SPT 'N' values recorded in the sandy silt to sand and silt ranged from 6 to 21 blows for 0.3 m penetration, indicating a loose to compact relative density. Measured moisture contents in the sandy silt to sand and silt ranged from 9 percent to 25 percent.

The results of grain size distribution analyses conducted on samples of the sandy silt to sand and silt are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B3 in Appendix B.

Soil Particle	Sandy Silt/ Sand and Silt (percent)
Gravel	0 to 7
Sand	21 to 36
Silt	58 to 73
Clay	4 to 6

## 5.6 Bedrock

The soils described above are underlain by basalt bedrock. The bedrock was grey to black with steeply dipping white cemented joints. Occasional mechanical breaks were noted throughout the bedrock cores. The bedrock is generally described as slightly weathered. Bedrock was proved by coring in Boreholes CO17-02 and CO17-05. Table 5.1 summarizes depths and elevations to the top of bedrock and refusal.

**Table 5.1 - Depths and Elevations of Top of Bedrock**

Borehole	Top of Bedrock		Comment
	Depth (m)	Elevation (m)	
CO17-01	7.7	416.0	Auger refusal
CO17-02	7.9	417.2 <sup>(1)</sup>	Bedrock
CO17-03	9.9	413.6	Auger refusal
CO17-05	8.5	416.6 <sup>(1)</sup>	Bedrock

<sup>(1)</sup> Proved by coring



Total Core Recovery (TCR) in the bedrock ranged from 100% with Solid Core Recovery (SCR) ranging from 81% to 98%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 71% to 88%, indicating fair to good rock quality.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 4.

Average unconfined compressive strengths (UCS) of the rock ranged between 138 MPa and 219 MPa, indicating the rock is very strong. An UCS of the rock measured in Run 3 of Borehole CO-17-02 was 27.0 MPa, indicating a medium strong rock. These estimated rock strength values are interpreted from point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results and photographs of bedrock cores are presented in Appendix B.

## 5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the open boreholes are summarized in the Table 5.2.

**Table 5.2 - Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
CO17-01	July 9, 2017	0.5	423.2	Open borehole
CO17-02	July 20, 2017	1.9	423.2	Open borehole
CO17-03	July 9, 2017	0.5	423.0	Open borehole
CO17-04	July 19, 2017	Dry	-	Open borehole
CO17-05	July 19, 2017	3.4	421.7	Open borehole
CO17-07A	July 20, 2017	Dry	-	Open borehole
CO17-07B	July 20, 2017	Dry	-	Open borehole
CO17-08	July 20, 2017	Dry	-	Open borehole

The upstream and downstream water levels of Cobb Bay Creek were measured at Elevation 423.51 m and 423.50 m, respectively, in April 2016, as shown on drawings provided by Hatch.

Groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.



## 6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silt from Borehole CO17-03, and a sample of the creek water obtained at the culvert inlet, taken from the inlet area, were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

**Table 6.1 - Analytical Test Results**

Parameter	Units (Soil)	Units (Water)	Test Results	
			CO17-03 SS 4 Depth 1.8 m	Cobb Bay Creek
			(Soil Sample)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	1.2	1.7
Sulphate	µg/g	mg/L	46	0.6
pH	No unit	No unit	8.65	7.70
Electrical Conductivity	µS/cm	µS/cm	83	78
Resistivity	Ohms.cm	Ohms.cm	12000	12800
Redox Potential	mV	mV	295	301

## 7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Stephen Hillier of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, B.A.Sc. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT and Ms. R. Palomeque Reyna,



The report was reviewed by Mr. Jason Lee, P.Eng and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

### 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


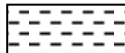



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ( $W_L < 30\%$ ).
		CI	Inorganic clays of medium plasticity, silty clays. ( $30\% < W_L < 50\%$ ).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa) (psi)	Field Estimation of Hardness*	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

# RECORD OF BOREHOLE No CO17-01

1 OF 1

METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 543 003.8 E 233 456.8 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Tripod/Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.09 - 2017.07.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
423.7	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy <b>SILT</b> , with organics, rootlets Very Loose to Loose Dark Brown Moist		1	SS	2	▽	423										0 4 87 9
422.5			2	SS	6												
1.2	<b>SILT</b> , trace to some sand, trace clay Dense to Loose Grey Wet		3	SS	46		422										
			4	SS	12												
			5	SS	8		421										
420.1							420										
3.6	Sandy <b>SILT</b> , trace clay Loose Grey Wet		6	SS	8											0 21 73 6	
							419										
			7	SS	9	418											
							417										
416.0																	
7.7	END OF BOREHOLE AT 7.7m UPON AUGER REFUSAL WATER LEVEL AT 0.5m FROM SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CO17-02

1 OF 2

METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 993.7 E 233 460.3 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
425.1	GROUND SURFACE						20   40   60   80   100	20   40   60	W <sub>P</sub> W   W <sub>L</sub>					
0.8	ASPHALT: (25mm)		1	GS										
424.5	SAND and GRAVEL, trace silt Brown Moist (FILL)													
0.6	SAND, some gravel Compact to Loose Brown Moist (FILL)		2	SS	13									
			3	SS	7									
422.7														
2.4	PEAT, trace sand, fibrous Very Loose Dark Brown Wet		4	SS	1									
422.1														
3.0	SILT, trace to some clay Compact to Very Loose Grey Wet		5	SS	12									
	Low SPT "N" values due to hydraulic ground disturbance from approx. elevation 420.5m to 418.0m		6	SS	1									
			7	SS	1									
			8	SS	30/ 0.050									
417.2														
7.9	BEDROCK BASALT, highly weathered, grey to white bands, occasional mechanical breaks		1	RUN										
			2	RUN										
											</			


Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CO17-02 2 OF 2 METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 993.7 E 233 460.3 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Coring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT      NATURAL MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20   40   60   80   100					W <sub>P</sub> W      W <sub>L</sub>				
	Continued From Previous Page																
	<b>BEDROCK BASALT</b> , slightly weathered, grey to white bands, occasional mechanical breaks						415								1	RUN #3 TCR=100% SCR=98% RQD=88% UCS=150MPa (Average)	
			3	RUN				414									0
413.8															1		
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 1.9m BELOW SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 6.1m, GRAVEL TO 0.4m, CONCRETE TO 0.05m THEN ASPHALT TO SURFACE.																

# RECORD OF BOREHOLE No CO17-03

1 OF 2

METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 976.8 E 233 457.2 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Tripod/ Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.09 - 2017.07.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
423.5	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy <b>SILT</b> , with organics, occasional rootlets, occasional wood fragments		1	SS	8		423										0 0 89 11
422.9	Compact Dark Brown		2	SS	35		422										
0.6	Wet  <b>SILT</b> , trace to some clay, occasional sand seams Dense to Compact Grey Wet		3	SS	35		421										
			4	SS	33		420										
			5	SS	19		419										
							418										
418.9			6	SS	6											7 29 58 6	
4.6	Sandy <b>SILT</b> , trace clay and gravel Loose to Compact Grey Wet					417											
						416											
			7	SS	21	415											
						414											
			8	SS	16												

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CO17-03 2 OF 2 METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 976.8 E 233 457.2 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Tripod/ Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.09 - 2017.07.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page				0.100												
	AUGER REFUSAL. WATER LEVEL AT 0.5m FROM SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

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RECORD OF BOREHOLE No CO17-04 1 OF 1 METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 975.5 E 233 436.1 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.19 - 2017.07.19 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE							PLASTIC LIMIT W <sub>P</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)		
425.1	GROUND SURFACE							20	40	60	80	100					
0.0 424.8	ASPHALT: (25mm)		1	GS			425							○			
0.3	SAND and GRAVEL, trace silt (FILL)																
	SAND, trace to some gravel, trace silt Brown Moist (FILL)																
423.6			2	GS			424							○			
1.5	PEAT, fibrous, organics, some wood pieces Dark Brown Wet		3	GS			423									○	
422.8																	
2.3	SILT, trace clay, Compact Grey Wet		4	GS										○			
			4	SS	11		422							○			0 0 91 9
421.4																	
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND COLD MIX ASPHALT TO SURFACE.																

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## METRIC

GWP#	6839-14-00	LOCATION	Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 979.3 E 233 444.1	ORIGINATED BY	STH
HWY	599	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2017.07.19 - 2017.07.19	CHECKED BY	RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa		WATER CONTENT (%)			
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W <sub>p</sub>	W <sub>L</sub>		
425.1	GROUND SURFACE											
423.9	<b>ASPHALT:</b> (25mm)  <b>SAND</b> and <b>GRAVEL</b> , trace silt Brown Moist (FILL)		1	GS								
423.3	<b>SAND</b> , trace to some silt Compact Grey Moist (FILL)		2	SS	16							
422.1	<b>PEAT</b> , organics, occasional roots and rootlets, fibrous Very Loose Dark Brown Wet		3	SS	2							
422.1	<b>SAND</b> and <b>SILT</b> , trace clay Loose Grey Wet		4	SS	4							
421.1	<b>SILT</b> , trace sand, trace clay, Very Loose Grey Wet  Low SPT "N" values due to hydraulic ground disturbance from approx. elevation 420.5m to 417.0m		5	SS	8							
416.6	<b>BEDROCK BASALT</b> , slightly weathered, grey to black with white bands, cemented joints		6	SS	3							
416.6			7	SS	1							
416.6			8	SS	1							
416.6			1	RUN								

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity


RECORD OF BOREHOLE No CO17-05 2 OF 2 METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 979.3 E 233 444.1 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.19 - 2017.07.19 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
	Continued From Previous Page							20	40	60	80	100					

RECORD OF BOREHOLE No CO17-07A 1 OF 1 METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 997.2 E 233 467.5 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
425.1	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT: (25mm)		1	GS												
	SAND and GRAVEL, trace silt, trace clay Brown Moist (FILL)		2	GS												
423.9																
1.2	END OF BOREHOLE AT 1.2m UPON AUGER REFUSAL, BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND GRAVEL TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.															

# RECORD OF BOREHOLE No CO17-07B

1 OF 1

METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 542 998.0 E 233 468.3 ORIGINATED BY STH  
 HWY 599 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
425.1	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (25mm)						425										
	SAND and GRAVEL, trace silt, trace clay, occasional cobbles Brown Moist (FILL)						424										
423.6			1	SS	50/												
1.5	END OF BOREHOLE AT 1.5m UPON AUGER REFUSAL, BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND GRAVEL TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.				0.0												

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RECORD OF BOREHOLE No CO17-08

1 OF 1

METRIC

GWP# 6839-14-00 LOCATION Cobb Bay Creek Culvert, MTM NAD 83 Zone 15 N 5 543 001.9 E 233 474.9 ORIGINATED BY STH  
HWY 599 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
425.1	GROUND SURFACE																
0.0	ASPHALT: (25mm)		1	GS												36 56 8 (SI+CL)	
	SAND and GRAVEL, trace silt, occasional cobbles Compact Brown Moist (FILL)																
423.6			2	SS	24												
1.5	END OF BOREHOLE AT 1.5m UPON AUGER REFUSAL, BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS AND GRAVEL TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																



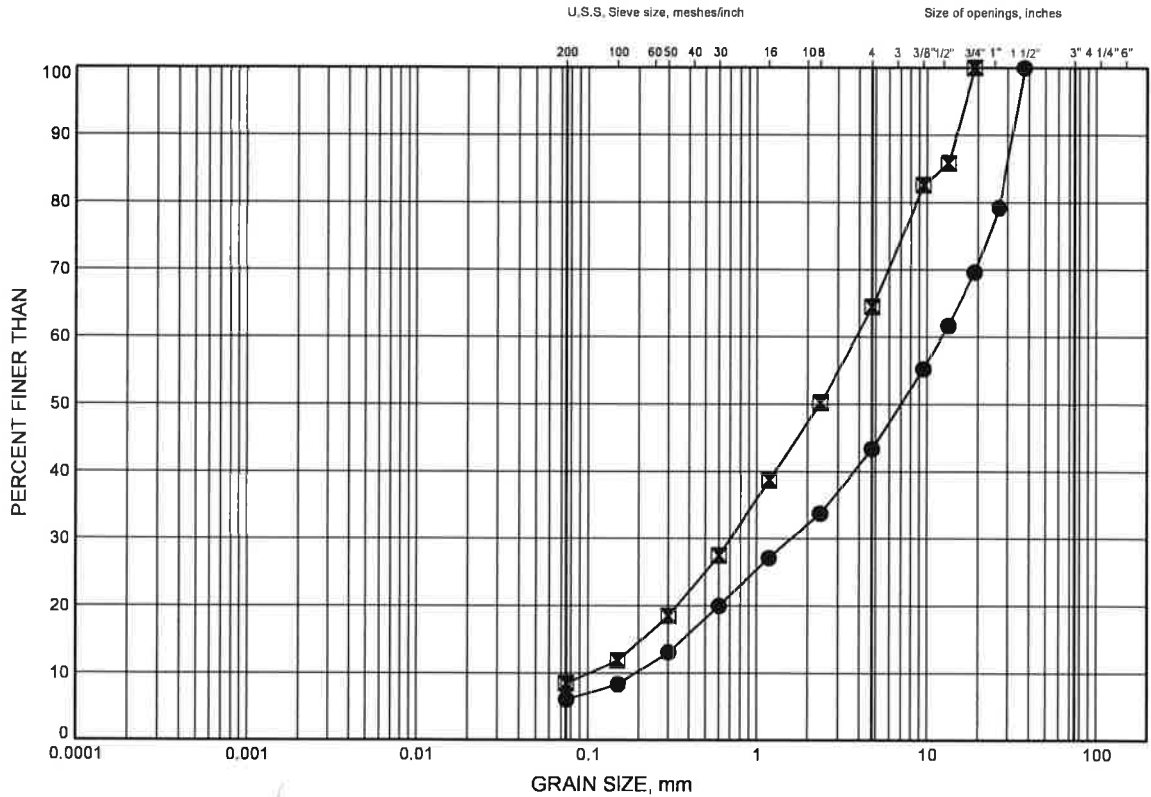
## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results And Rock Core Photos**

# Cobb Bay Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

## SAND and GRAVEL FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CO17-07A	0.9	424.2
⊠	CO17-08	0.3	424.8

Date October 2017

GWP# 6839-14-00

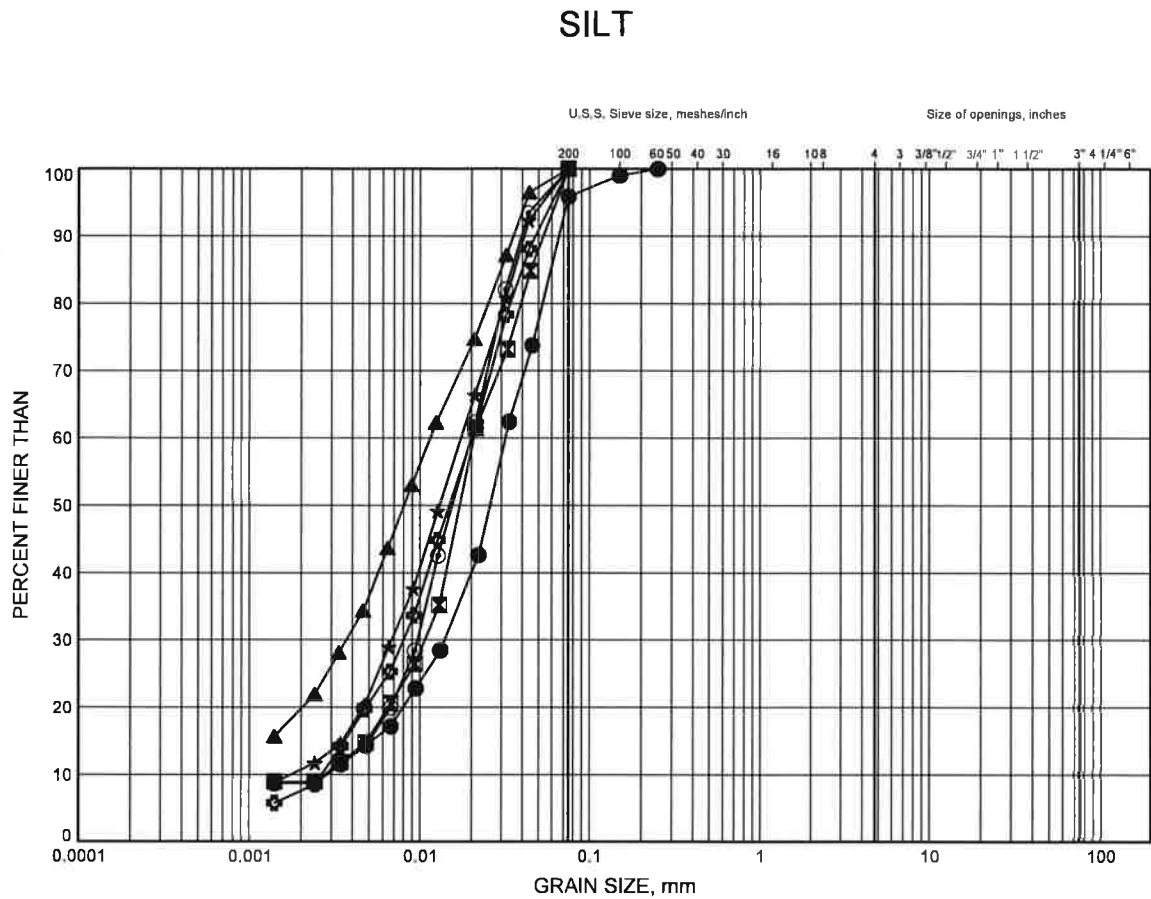


Prep'd AN

Chkd. RPR

# Cobb Bay Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CO17-01	2.1	421.6
⊠	CO17-02	3.4	421.7
▲	CO17-02	6.4	418.7
★	CO17-03	1.5	422.0
⊙	CO17-04	3.4	421.7
⊕	CO17-05	7.9	417.2

Date October 2017

GWP# 6839-14-00



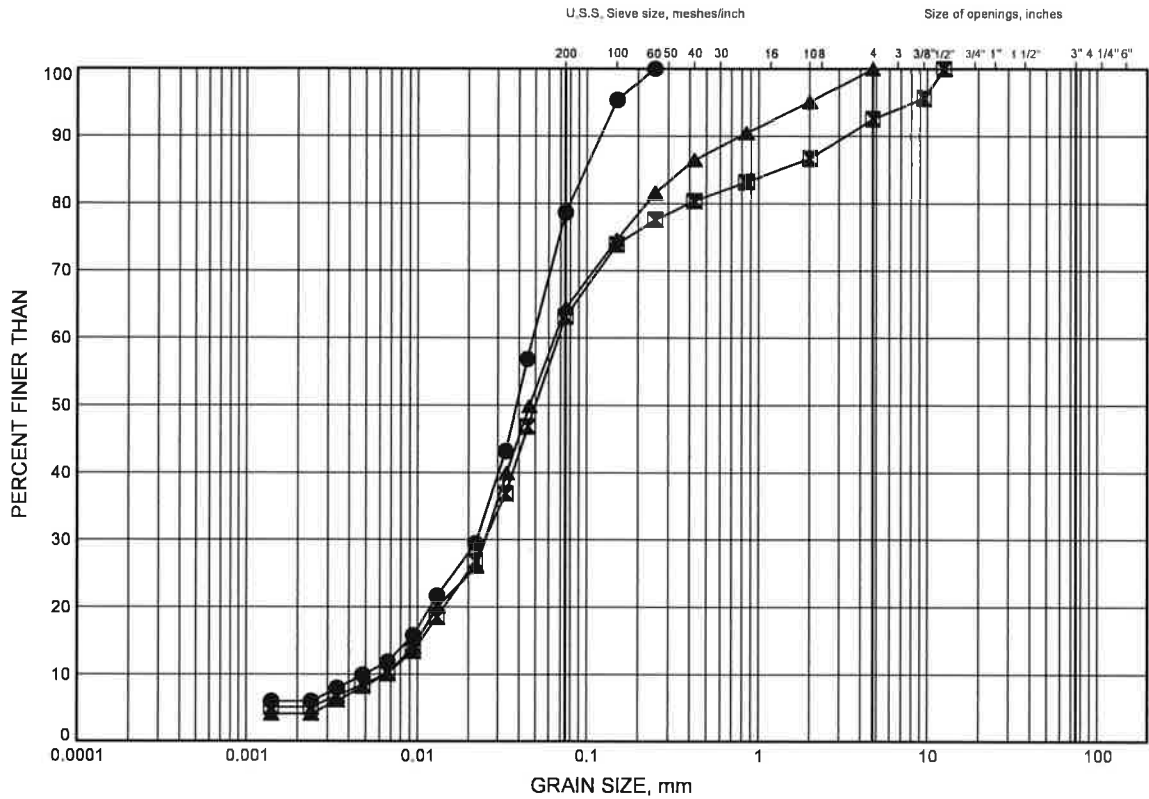
Prep'd AN

Chkd. RPR

# Cobb Bay Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

## Sandy SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CO17-01	4.0	419.7
⊠	CO17-03	7.9	415.6
▲	CO17-05	3.4	421.7

Date October 2017

GWP# 6839-14-00



Prep'd AN

Chkd. RPR



**THURBER ENGINEERING LTD.**

# POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 17077  
 Client: HATCH  
 Project Name: Cobb Bay Creek  
 Core Size: NQ BH No : CO17-05

Date Drilled: 19-Jul-17  
 Date Tested: 23-Aug-17  
 Tester: ISP  
 Reviewed by: CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	8.8	A	18.3	47.0	56.3	5.5	131.9	Basalt	Very Strong
2	1	9.0	D	22.1	47.0	154.7	9.2	221.0	Basalt	Very Strong
3	1	9.1	A	6.0	47.0	55.2	1.8	43.7	Basalt	Medium Strong
4	1	9.4	D	15.5	47.0	154.7	6.5	155.7	Basalt	Very Strong
5	1	9.6	A	14.3	47.0	53.7	4.5	106.8	Basalt	Very Strong
6	1	9.9	D	16.6	47.0	154.7	6.9	165.9	Basalt	Very Strong
7	2	10.2	A	10.4	47.0	55.3	3.2	76.3	Basalt	Strong
8	2	10.6	D	14.2	47.0	154.7	5.9	142.4	Basalt	Very Strong
9	2	10.9	A	10.6	47.0	55.5	3.2	77.7	Basalt	Strong
10	2	11.3	D	31.0	47.0	154.7	12.9	310.5	Basalt	Extremely Strong
11	2	11.6	A	14.8	47.0	56.0	4.5	107.6	Basalt	Very Strong
12										
13										
14										
15										
16										
17										
18										
19										
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31										
32										
33										
34										
35										

\* It is ideal to perform axial test on core specimens with D/L ratio of  $1.1 \pm 0.1$

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

\* Diametral Test should have  $0.7 \times D$  on either side of test point.

\* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016



THURBER ENGINEERING LTD.

## POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 17077  
 Client: HATCH  
 Project Name: Cobb Bay Creek  
 Core Size: NQ BH No : CO17-02

Date Drilled: 20-Jul-17  
 Date Tested: 23-Aug-17  
 Tester: ISP  
 Reviewed by: CZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	8.1	D	12.5	47.0	154.7	5.2	125.6	Basalt	Very Strong
2	1	8.4	A	39.5	47.0	54.2	12.2	293.5	Basalt	Extremely Strong
3	1	8.6	D	15.4	47.0	154.7	6.4	154.7	Basalt	Very Strong
4	2	9.0	A	41.0	47.0	56.0	12.4	297.6	Basalt	Extremely Strong
5	2	9.1	D	24.4	47.0	154.7	10.2	244.8	Basalt	Very Strong
6	2	9.4	A	37.5	47.0	51.8	12.0	289.2	Basalt	Extremely Strong
7	2	9.5	D	17.5	47.0	154.7	7.3	175.3	Basalt	Very Strong
8	2	10.1	A	10.5	47.0	56.2	3.2	76.1	Basalt	Strong
9	2	10.4	D	22.8	47.0	154.7	9.5	228.2	Basalt	Very Strong
10	3	10.7	A	33.6	47.0	54.1	10.4	250.3	Basalt	Extremely Strong
11	3	10.9	D	19.8	47.0	154.7	8.3	198.5	Basalt	Very Strong
12	3	11.2	A	3.6	47.0	54.1	1.1	27.0	Basalt	Medium Strong
13										
14										
15										
16										
17										
18										
19										
20										
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28										
29										
30										
31										
32										
33										
34										
35										

\* It is ideal to perform axial test on core specimens with D/L ratio of  $1.1 \pm 0.1$

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

\* Diametral Test should have  $0.7 \times D$  on either side of test point.

\* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016



0 m

50 m

100 m

150 m

Core Photo 1: Borehole CO17-02 Run 1 to Run 3 (7.9 m to 11.3 m)



0 m

50 m

100 m

150 m

Core Photo 2: Borehole CO17-05 Run 1 to Run 2 (8.5 m to 11.7 m)



Client  
SGS LIMS Number  
Analysis Package:

Attention: Cory Zanatta  
Project#: 17077  
Thurber Engineering Ltd.  
CA15302-AUG17  
Corrosivity (Soil)

SGS Canada Inc.  
185 Concession St. Box 4300  
Lakefield, Ont., Canada,  
K0L 2H0

Sample ID	Unit	PR17-02 SS7	KE 17-03 SS5	ME 17-03 SS3	TU 17-02 SPT5	CO 17-03 SS4	AG 147-02 SS4
Sample Date/Time		30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17	30-Jul-17
Moisture	%	15.6	7.0	7.7	22.2	15.6	21.0
pH	no unit	8.25	6.40	8.27	8.14	8.65	8.33
Corrosivity Index	none	4.5	1.0	1.0	1.0	4.0	1.0
Soil Redox Potential	mV	325	338	303	301	295	290
Sulphide	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride	mg/L	6.9	240	2.4	25	1.2	150
Sulphate	mg/L	26	10	10	1.2	46	6.1
Conductivity	uS/cm	49	269	35	81	83	213
Resistivity (calculated)	ohms.cm	20300	3720	28700	12400	12000	4690

Corrosivity Scale according to AWWA C-105.

An index greater than 10 indicates the  
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem  
Project Specialist  
Environment, Health and Safety

## Certificate of Analysis

SGS Canada Inc.  
185 Concession St. Box 4300  
Lakefield, Ont., Canada, K0L 2H0



Client  
SGS LIMS Number  
Analysis Package:

Attention: Cory Zanatta  
Project#: 17077 Hwy 599  
Thurber Engineering Ltd.  
CA15314-JUN17  
Corrosivity (Solution)

Sample ID	Unit	RL	Tug Creek	Pratt Creek	Mile Creek	Cobb Bay	Kekwanzik Lake	Agimak River
			10-Jun-17 12:10	10-Jun-17 12:30	10-Jun-17 10:40	10-Jun-17 11:20	10-Jun-17 12:45	10-Jun-17 13:10
Sample Date/Time								
Temperature Upon Receipt	°C		10.0	10.0	10.0	10.0	10.0	10.0
Soil Redox Potential	mV		334	272	352	301	312	345
Sulphide	mg/L	0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
pH	no unit	0.05	7.78	7.81	7.62	7.70	7.38	7.26
Chloride	mg/L	0.04	2.1	2.9	2.7	1.7	8.8	7.8
Sulphate	mg/L	0.04	0.3	1.2	0.8	0.6	2.0	1.9
Conductivity	µS/cm	2	100	78	63	78	67	56
Resistivity (calculated)	ohms.cm		9990	12700	15800	12800	15000	17700

Corrosivity Index is based on the AWWA  
Corrosivity Scale according to AWWA C-105.  
An index greater than 10 indicates the  
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem  
Project Specialist  
Environment, Health and Safety

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at [http://www.sgs.com/terms\\_and\\_conditions\\_service.htm](http://www.sgs.com/terms_and_conditions_service.htm). (Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



## **Appendix C**

### **Selected Site Photographs**



**Photo 1: South side of Highway 599 at Cobb Bay Creek Culvert looking west**



**Photo 2: North side of Highway 599 at Cobb Bay Creek Culvert looking west**



**Photo 3: Highway 599 at Cobb Bay Creek Culvert looking east**



**Photo 4: Cobb Bay Creek Culvert outlet**

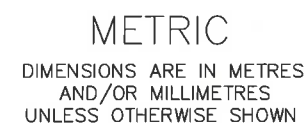


**Photo 5: Cobb Bay Creek Culvert inlet**



## **Appendix D**

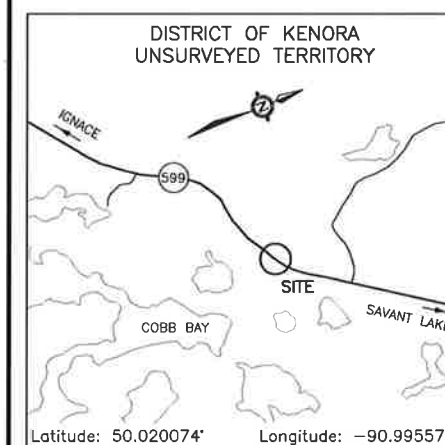
### **Borehole Locations and Soil Strata Drawings**



SHEET  
24



**THURBER ENGINEERING LTD.**

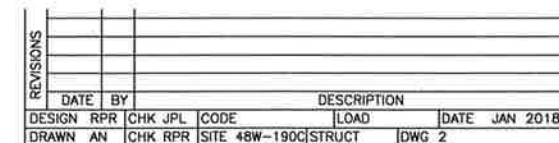


	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger/Casing/DCPT Refusal

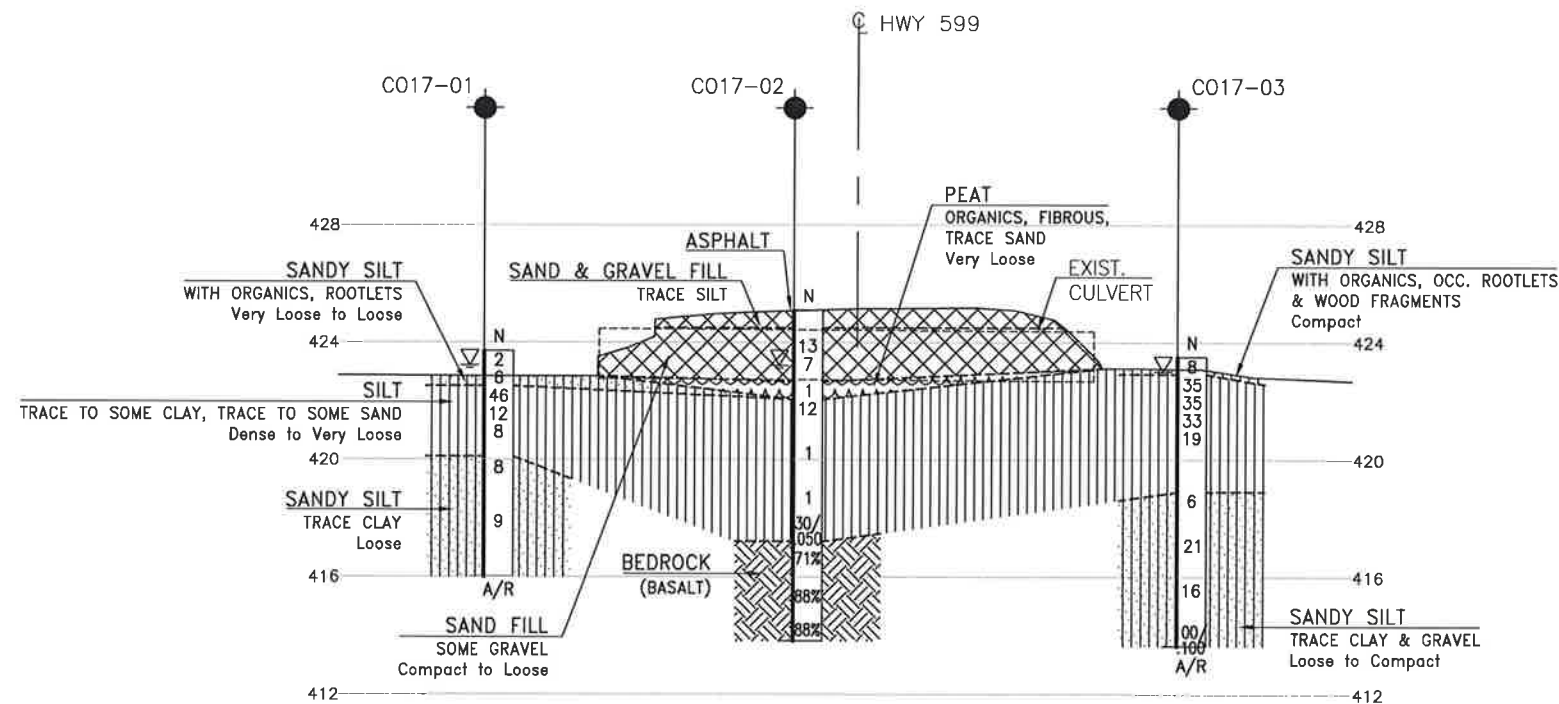
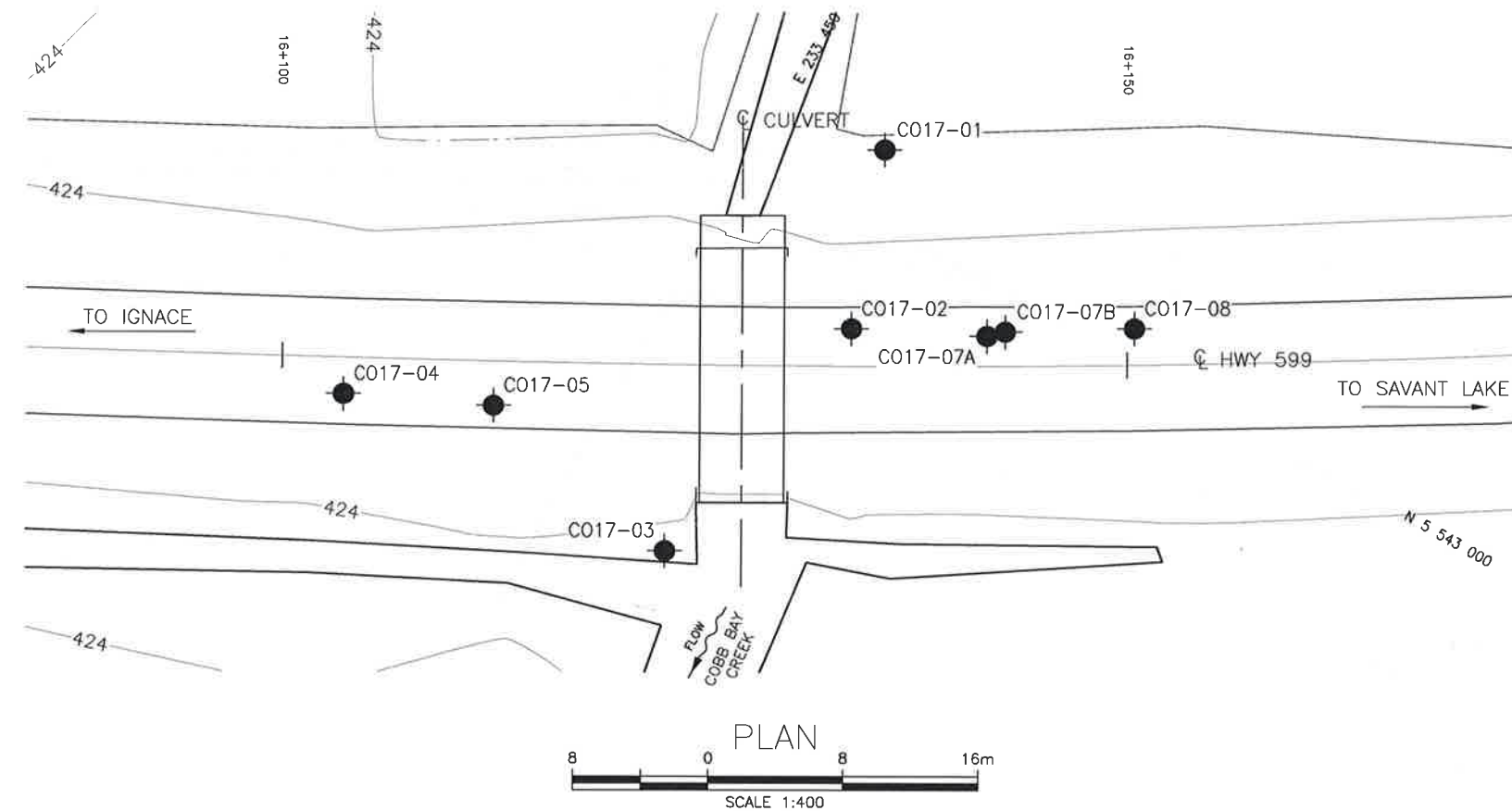
**-NOTES-**

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRE'S No. 52J-17



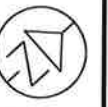
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METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No 2018-6002  
WP No 6840-14-01

HIGHWAY 599  
COBB BAY CREEK CULVERT  
REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

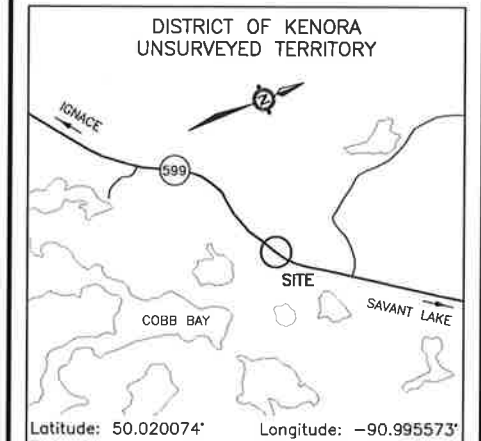


SHEET  
25

**HATCH**



THURBER ENGINEERING LTD.



LEGEND

- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- ↑ Head Artesian Water
- ⊥ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger/Casing/DCPT Refusal

NO	ELEVATION	NORTHING	EASTING
C017-01	423.7	5 543 003.8	233 456.8
C017-02	425.1	5 542 993.7	233 460.3
C017-03	423.5	5 542 976.8	233 457.2
C017-04	425.1	5 542 975.5	233 436.1
C017-05	425.1	5 542 979.3	233 444.1
C017-07A	425.1	5 542 997.2	233 467.5
C017-07B	425.1	5 542 998.0	233 468.3
C017-08	425.1	5 543 001.9	233 474.9

NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 15.

GEOCREs No. 52J-17



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK JPL	CODE
DRAWN	AN	CHK RPR	SITE 48W-190C/STRUCT
			LOAD
			DATE
			JAN 2018
			DWG 3